National Aeronautics and Space Administration

NASA

EXPLORESCIENCE

NASA SMD Level-1 Requirements

PI Launchpad
August 5, 2019

Dr. Jared Leisner

Program Scientist, Heliophysics Division
Science Mission Directorate

NASA Missions, Flowdown from Goals

- NASA missions are formulated and developed based upon the flowdown of requirements.
  - *Goal*: A broad scientific effort that is part of a larger strategy to address a program's objectives. A mission investigation will make progress towards the mission's goals, but is not expected to completely achieve them.
  - *Objective*: A focused scientific effort that is part of a larger strategy to address a mission goal. A project investigation must completely achieve a mission objective.
  - *Level-1 Requirements*: Those scientific determinations and/or results required for successful completion of the mission's objectives. Level-1 Requirements do not specify implementation details for the mission.
  - *Level-2 Requirements*: The measurement, payload, system, subsystem, mission, or other details that flow down from Level-1 Requirements. Level-2 Requirements are the first level of implementation details for the mission.
  - *Mission Success Criteria*: The Level-1 Requirements that must be met for NASA to declare the mission a success. These are set by NASA and SMD policy.
- When planning a mission, scientists tend to move from "this is the type of thing I want to do" (Goal/Objective) directly to "this is the mission that I want to fly" (Level-2 and lower-level requirements).
- This misses the most important part of the mission formulation process: the Level-1 Requirements.
  - Every mission requirement flows from the Level-1 Requirements.

Level-1 Requirements

- Level-1 Requirements are the scientific determinations and/or results that NASA and the mission agree represent the minimum that must be accomplished for an objective's completion.
- What purpose(s) do Level-1 Requirements serve?
  - Scientific
    - Focus the mission science…
      - …priorities: Define the *science* needs for each objective, and the scientific space for descopes.
      - …proposal: Provide the framework to write your proposal within and around.
      - …publicity: Informs coherent messaging on the work to be done and the objectives to be achieved.
    - Quantify the science objectives in terms that can flow into mission requirements
    - Define the requirements that mission success is measured against
    - Assist HQ's portfolio management via understanding synergies, overlap, and gaps
  - Engineering
    - Bound the engineering trade space, and give engineers a framework within which to find solutions
  - Programmatic
    - Serve as the contract between NASA HQ and the mission on work to be accomplished
    - Define the level at which the mission *must* seek HQ approval for changes; and therefore define the levels at which the mission *need not* seek HQ approval

Myths about Level 1s

- My science can't be written in terms of requirements.
  - All science can be written in terms of properly scoped Level 1s.
  - Level-1 Requirements are the way one can tell that you have succeeded, so any potentially successful investigation can write them.
  - If you don't have science-based Level 1s, you can't clearly demonstrate flow between science objectives and lower-level requirements.
- Level-1 Requirements stifle my scientific creativity.
  - Level 1s provide the framework that your mission must be developed in. When you have that base, you gain the freedom to explore innovative solutions within it while still explicitly showing that they enable scientific success.
- Level-1 Requirements can not capture all of the science that we will do.
  - Level 1s are not intended to capture all science that a mission will do or all science that can be done with the mission data.
- Level-1 Requirements are hard to develop, measurement requirements are easier.
  - Level 1s are easy. If you have an achievable science objective, you already have your Level 1s in mind.
  - Without Level 1s, you can not clearly demonstrate that your measurement requirements are sufficient and necessary to achieve the science objective.
  - Writing requirements is a skill. Once learned, it becomes a natural part of mission formulation.

Level-1 Requirements

- Level-1 Requirements are
  - Level-1 MadLib: The mission shall [quantitative scientific-result verb] [aspect of the physical system] [preposition] [verification parameter(s)].

- Objective: Characterize the geologic history of the surface of Planet Acme.
  - L1-1: The mission shall identify all geologic units larger than XX km by XX km for 80% of the surface.
  - L1-2: The mission shall map all geologic contacts longer than YY km for 80% of the surface and with a positional accuracy of ZZ km.
  - L1-3: The mission shall map all exposed geologic faults longer than YY km for 80% of the surface and with a positional accuracy of ZZ km.
  - L1-4: The mission shall determine the relative age of all geologic units larger than XX km by XX km that are in contact for 80% of the surface.
  - L1-5: The mission shall determine the absolute age of all geologic units larger than XX km by XX km with an accuracy of Z%.

Questions?